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(54) Abstract Title
Compact varistor and spark gap surge arrester

(57) The surge arrester comprises a spark gap formed by two electrode plates 1 held apart from one another by means of a spacer 3 made of insulating material, with a disc-shaped varistor 2 place in direct contact with at least one of the electrode plates. Also disclosed is a compact varistor and spark gap surge arrester where the varistor forms one or both of the electrode plates of the spark gap or the varistor is arranged as a spacer between the electrode plates forming the spark gap. Figs 4, 5 and 6 show more than one spark gap while figs. 9 and 10 show ignition tips in the spark gap.

Fig.1

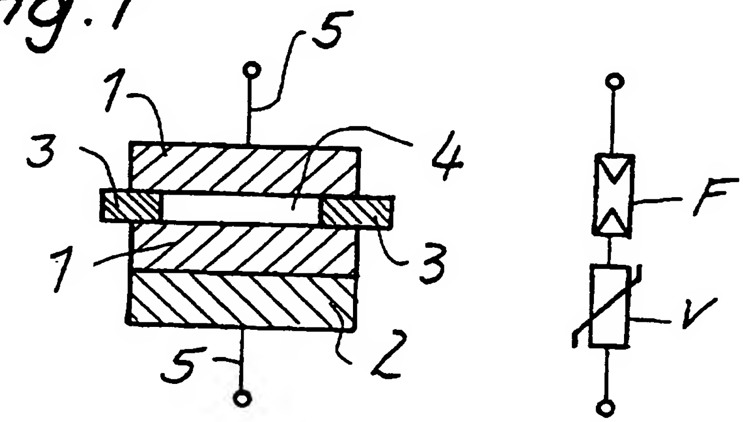

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Fig.1

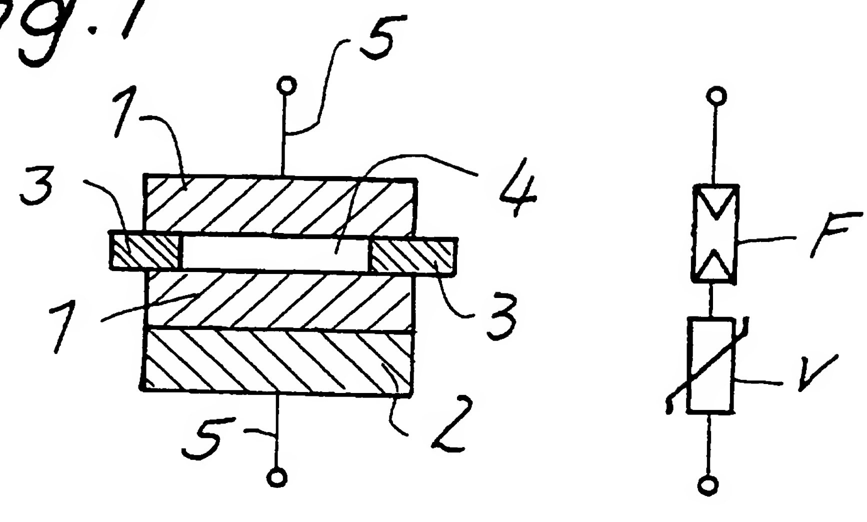


Fig.2

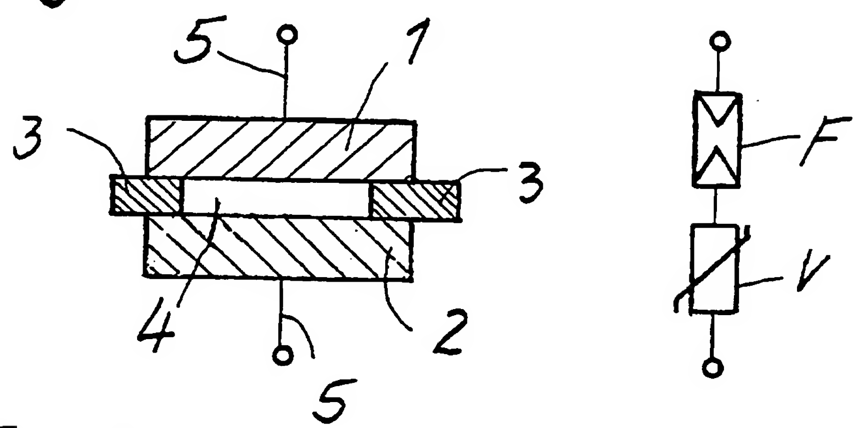


Fig.3

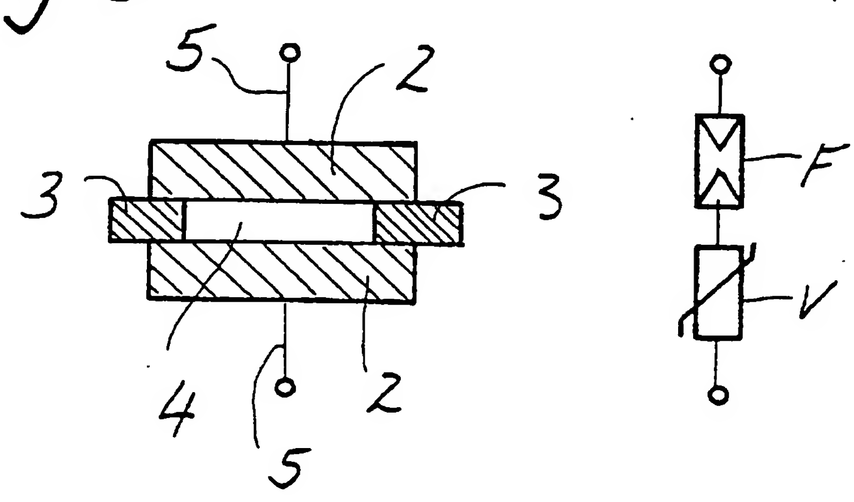


Fig. 4

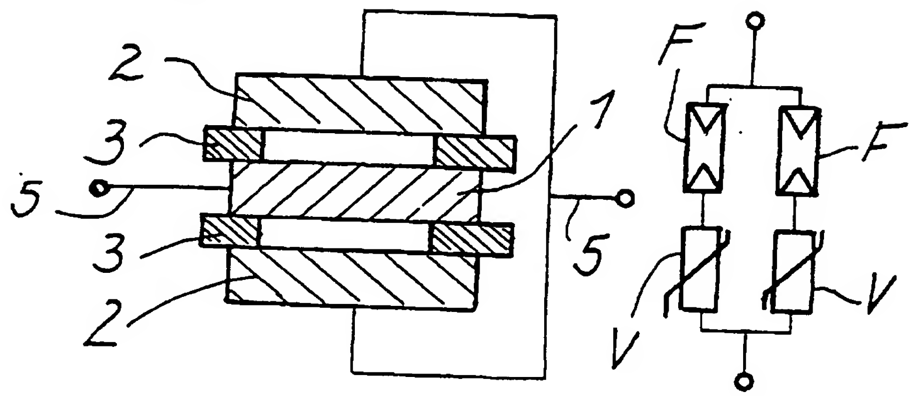


Fig. 5

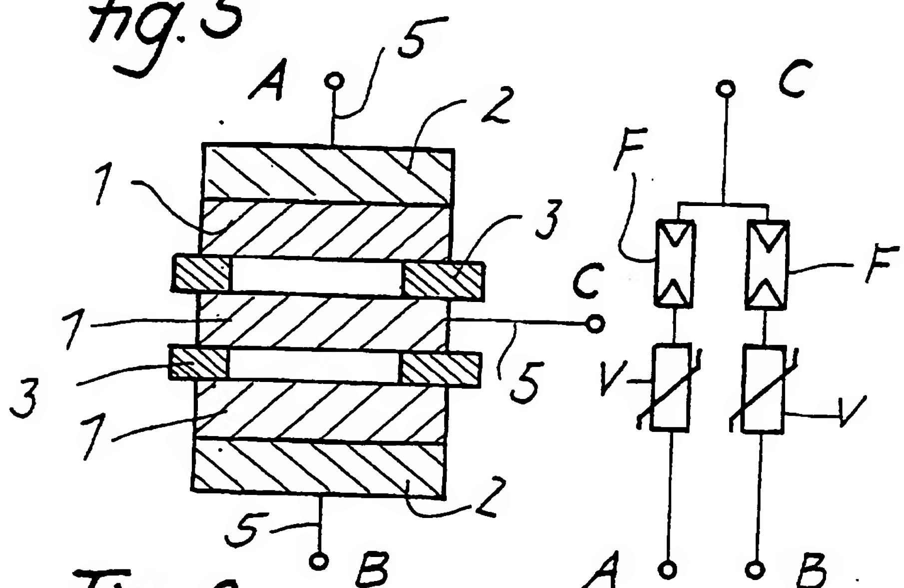


Fig. 6

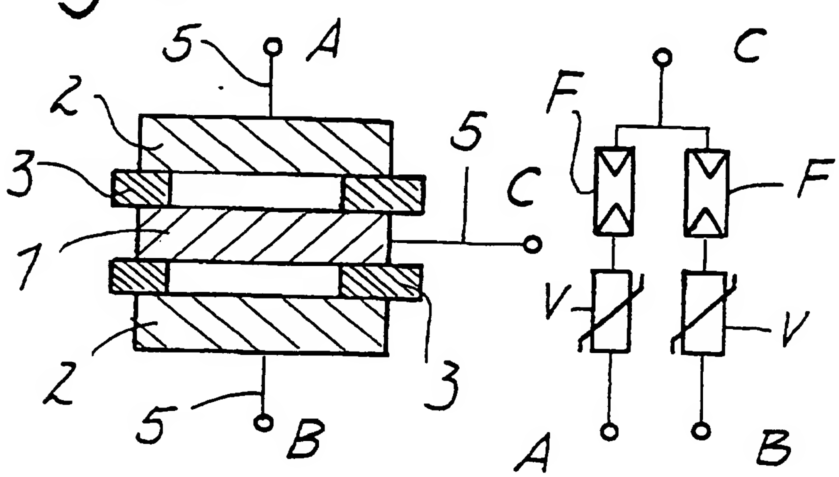


Fig. 7

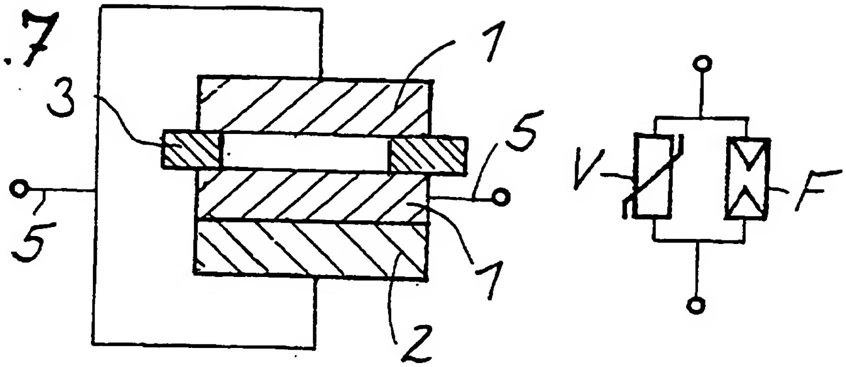


Fig. 8

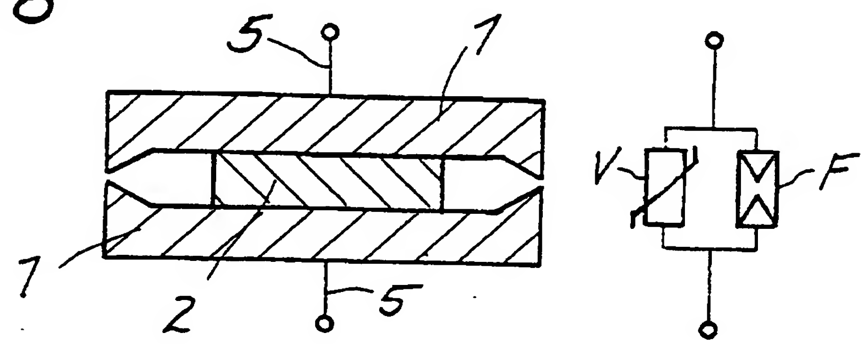


Fig. 9

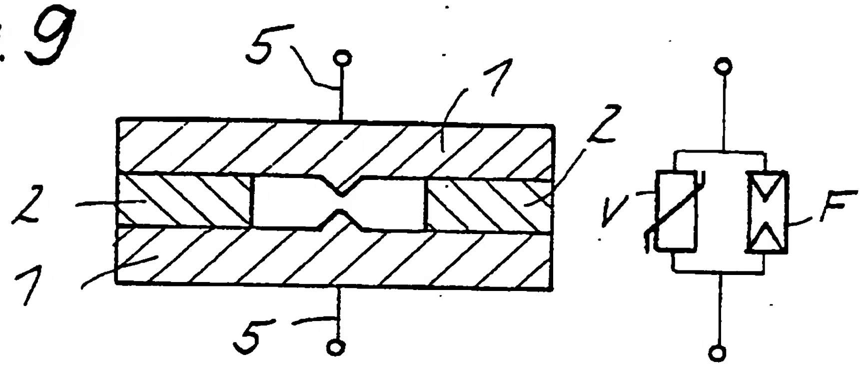
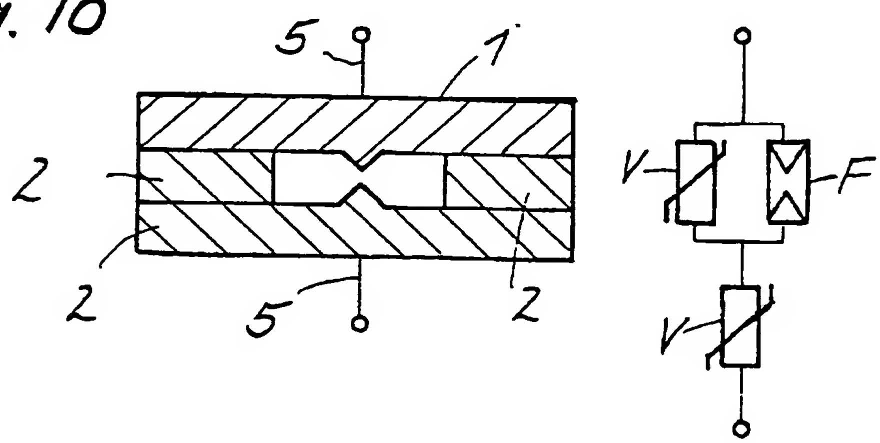


Fig. 10



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Circuit arrangement for protecting electrical installations against overvoltage occurrences

The invention relates to a circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap.

Many such circuit arrangements are known in the prior art and have varistors and spark gaps connected in series or in parallel. The spark gap and the varistor are each provided as an independent component connected, by means of suitable wiring, to the other component and to the circuit which is to be protected.

On the basis of this prior art, the invention is based on the objective of creating a circuit arrangement of this generic type, which allows such components to be of compact design.

As a means of achieving this objective, the invention proposes that the spark gap be formed by two electrode plates held apart from one another by means of a spacer made of insulating material, and that a disc-shaped varistor be placed on at least one electrode plate in direct contact, the connecting conductors leaving from the side of the free electrode of the electrode plate and from the free side of the varistor and/or from the electrode plate.

An alternative solution is characterised in that the spark gap is formed by an electrode plate and a disc-shaped varistor which is held apart from the latter by means of a spacer made of insulating material and whose surface facing the electrode plate forms the second electrode of the spark gap, the connecting conductors primarily being provided on the mutually distant sides of the electrode plate and of the varistor.

A further alternative solution is characterised in that the spark gap is formed by two disc-shaped varistors which are held apart by means of a spacer made of insulating material and whose mutually facing surfaces form the electrodes of the spark gap, the connecting conductors primarily being provided on the mutually distant sides of the varistors.

A further alternative is characterised in that an electrode plate is arranged between two disc-shaped varistors with spacers made of insulating material being arranged in between, said electrode plate forming one electrode of the spark gap while those two surfaces of the varistors which face the electrode plate form the second electrodes of two spark gaps, the connecting conductors primarily being connected to the electrode plate and to those two surfaces of the varistors which are turned away from the electrode plate.

A preferred development is seen in that that side of the electrode plate which is turned away from the spacer has a second spacer placed on it, with a further electrode plate placed on this, that side of the latter electrode plate which is turned away from the spacer having a second disc-shaped varistor placed on it in direct contact, with connecting conductors primarily leaving from the exposed surfaces of the two varistors and from the central electrode plate.

A further alternative solution is characterised in that a varistor is arranged as a spacer between two electrode plates forming the spark gap.

In this case, the varistor is preferably disc-shaped, and its diameter is smaller than the diameter of the electrode plates.

As an alternative, the varistor can be annular, and its external diameter can be the same as the diameter of the electrode plates.

It is further preferred to provide projections, whose tips lie on the same radius, protruding from the electrode plates in the area not occupied by the varistor on the sides turned towards each other.

A further alternative solution to the object is characterised in that an electrode plate and a disc-shaped varistor have a further varistor, which is smaller in diameter or is annular, arranged between them as a spacer, with ignition tips or similar projections preferably protruding from the electrode plate and the disc-shaped varistor.

An additional preference is for the electrode plates to be made of graphite.

The compact design is beneficial if the electrode plates are formed by shallow circular discs.

For the same reason, the varistors are preferably designed as shallow circular discs or rings.

Furthermore, the spacers are preferably made of PTFE.

A further preference is for the spacers to be shallow annular discs.

A particularly preferred development is seen in that the planar surfaces of the disc-shaped varistors are provided with a highly electrically conductive coating, primarily of silver, aluminium, or graphite, preferably only on the surface which does not form the electrode of the spark gap.

Coating is preferably carried out only on the side which is occupied by contacts of connecting conductors. In particular, there should be no metal coating provided on the side which is a constituent part of the spark gap, because the coating could otherwise be vaporised in the event of an overvoltage occurring, which is disadvantageous for the operation of the component as a whole.

An additional preference is for the 1-mA point of the varistor to be far below the operating voltage of the spark gap, so that, in the event of an occurrence, the residual voltage of the varistor serves as an opposing voltage for extinguishing the arc of the spark gap.

The invention provides extremely compact combinations of spark gaps and varistors presenting a high level of effectiveness with an extremely low space requirement.

These components can be used in the form of a series circuit or else in the form of a parallel circuit of varistors and spark gaps, depending on the connection of the connecting conductors.

In this case, in contrast to conventional use in a series circuit comprising spark gaps and a varistor as a valve-type surge arrester according to the invention, the emphasis is placed on the dissipation properties of the spark gap. The respective varistor is chosen such that its 1-mA point is far below the operating voltage of the spark-gap surge arrester. This achieves a considerably more beneficial follow-current extinguishing capability as compared with a pure spark-gap surge arrester. The residual voltage of the varistor is then used as an opposing voltage for extinguishing arcs. Significant advantages are achieved by comparison with the arrangement of pure varistor surge arresters. A varistor of the same or similar physical size has, for the same maximum energy density and very low residual voltage, a much higher ability to withstand lightning stroke currents and can therefore also be used in performance ranges where pure varistor technology fails. The combination of graphite spark-gap technology with varistor technology allows combined surge arresters to be of very compact design. Partial or complete use of the varistors as spark-gap electrodes allows the design to be far more compact. Multi-pole combined surge arresters can also be

produced very compactly as a result of combined varistor/graphite spark-gap technology. An example described below will be used to illustrate significant advantages:

If a varistor surge arrester is used in energy supply lines, then a 275-V type is usually chosen. This has a very limited ability to withstand lightning stroke currents, however. Hence, according to the invention, only a 75-V type is used, however. In normal operation, this will be decoupled from the mains voltage by the spark gap of a series circuit in series. Upon loading with a lightning stroke current, for example, the spark gap will arc across, however, and make contact with the varistor. Since, in this case, the varistor has a much lower residual voltage, this means that, for the same lightning stroke current, far less energy is input into the varistor. Hence, a varistor of the same physical size and the same maximum permissible energy density can withstand a higher lightning stroke current. The problem caused by the fact that the varistor is now at mains voltage is solved in that the solution according to the invention achieves very good follow-current extinguishing properties, and the varistor is therefore safely isolated from the mains again after loading with the lightning stroke current.

A parallel circuit comprising varistors and spark gaps is also possible with the compact design according to the invention. In this case too, the compact design of parallel-connected varistors and graphite spark gaps also affords advantages in terms of miniaturising the circuit arrangement. Here too, the possibility of direct contact of the varistor and the spark-gap electrode can be used. In addition, the varistor can be integrated in the spark gap such that, besides its electrical function as a surge arrester, it also takes on the mechanical function of the spacer for the spark gap. In this case, the graphite electrode is designed such that flashover at the

varistor/air boundary layer is reliably avoided. This can be achieved by various measures:

When there is a flow of current through the varistor, the electrical field component increases sharply, vertically with respect to the varistor/air boundary layer. A creeping discharge is therefore taken as a basis for the striking mechanism. However, the incipient voltage of the creeping discharge is far below that of a streamer breakdown, which occurs in air when there is a free breakdown. Hence, in order to avoid boundary layer flashover reliably at the varistor, either the striking mechanism of the spark gap also needs to be designed as a creeping arrangement, or creeping discharge at the varistor/air boundary area has to be prevented by field control. Field control can be achieved through careful construction of the graphite spark gap and optimisation by means of field simulation. Creeping discharge as a striking mechanism for the spark gap requires the use of a strongly dielectric material, since the incipient voltage of a creeping arrangement depends on the capacitance of the creep path, and hence strongly dielectric materials favour the inception of creeping discharge. If, during construction of the graphite electrodes, care is taken to ensure that a sufficiently high vertical E-field component occurs at the boundary layer between the dielectric and the air, this striking aid will reliably prevent flashover at the varistor. With very steep voltage pulses, it is no longer possible to co-ordinate the breakdown reliably using the aforementioned options. However, if advantage is taken of the fact that homogeneous field arrangements have significantly lower striking delay times than non-homogeneous ones (a creeping spark gap is such an non-homogeneous field arrangement), then a homogeneous spark gap with large surface area can influence the breakdown characteristic in such a way that voltages with a very high

du/dt ratio are also reliably struck in the spark gap. In addition, the low jitter of a homogeneous spark gap produces a very low residual voltage.

Illustrative embodiments of the invention are shown in the drawings, where:

Figures 1 to 10 show diagrammatic illustrative embodiments.

The drawings show diagrammatic illustrative embodiments of the circuit arrangement according to the invention. In each case, the compact circuit arrangement according to the invention is shown with an equivalent circuit diagram next to it, according to the function of the component. In all the embodiments, graphite electrodes 1 in the form of circular discs and varistors 2, also in the form of circular discs, are used.

In the circuit arrangement shown in Figure 1, the spark gap is formed by two electrode plates 1 held apart from one another by means of a spacer 3 made of insulating material. The spacer is an annular element which has a large free space 4 in the centre and projects radially outwards over the electrode plates 1. The electrode plates 1 and the disc-shaped varistor 2 coupled to them are of equal diameter. One of the electrode plates 1 has a disc-shaped varistor 2 placed on it in direct contact and fixed using suitable measures. In the illustrative embodiment, the connecting conductors 5 leave from the side of the free electrode of the top electrode plate 1 and from the free side of the varistor 2. The illustrative embodiment shown in Illustration 1 corresponds to the circuit arrangement as symbolised in Figure 1 next to the physical embodiment of the circuit arrangement. Thus, this is a circuit arrangement comprising a spark gap F and a varistor V.

In the circuit arrangement shown in Figure 2, the spark gap is formed by an electrode plate 1 (graphite electrode plate) and a disc-shaped varistor 2 which is held

apart from the latter by means of a spacer 3 made of insulating material. In this arrangement, that surface of the varistor which faces the electrode plate 1 forms the second electrode of the spark gap. The connecting conductors 5 are provided on the mutually distant sides of the electrode plate 1 and of the varistor 2. The equivalent circuit shows that this is also a series circuit comprising a spark gap and a varistor, with the physical size being considerably smaller than that of the embodiment shown in Figure 1.

In the embodiment shown in Figure 3, the spark gap is formed by two disc-shaped varistors 2 which are held apart by means of a spacer 3 made of insulating material. The mutually facing surfaces of the varistors form the electrodes of the spark gap. The connecting conductors 5 are provided on the mutually distant sides of the varistors 2. The equivalent circuit shows that this is also a series circuit comprising a spark gap and a varistor. This design is miniaturised and extremely effective when the varistors are used completely as spark-gap electrodes.

Figure 4 shows a further illustrative embodiment, distinguished by dual use of the graphite electrode for a higher load-carrying ability with a compact design. In this arrangement, an electrode plate (graphite electrode) is arranged between two disc-shaped varistors 2 with spacers made of insulating material 3 being arranged in between. This forms a spark gap between the mutually opposite surfaces of the varistor 2 and the electrode plates 1 in each case. The connecting conductors 5 are connected to those two surfaces of the varistors 2 which are turned away from the electrode plate 1, and are brought together to a common connection. The other connection is routed radially to the electrode plate 1. The equivalent circuit shows that this is a parallel circuit containing two series circuits comprising spark gaps and varistors.

Figure 5 shows a compact design achieved by making direct contact between spark gaps and varistors. In this case, similarly to the embodiment shown in Figure 1, that side of the electrode plate 1 which is turned away from the spacer 3 has a second spacer 3 placed on it, with a further electrode plate 1 placed on this. That side of the latter electrode plate which is turned away from the spacer 3 has a second disc-shaped varistor 2 placed on it in direct contact. The connecting conductors 5 leave from the exposed surfaces of the two varistors 2 and from the central electrode plate 1 (radially from this). The equivalent circuit shows the combination of two spark gaps with varistors.

In the configuration shown in Figure 6, a compact design is achieved by the partial use of the varistors as spark-gap electrode. This refinement essentially corresponds to the refinement shown in Figure 4, with the electrical connections 5 merely being connected differently, as shown by the associated equivalent circuit diagram.

In the embodiment shown in Figure 7, there is a parallel circuit comprising a spark gap and a varistor. In this case too, a compact design is achieved by making direct contact between spark gap and varistor. This embodiment essentially corresponds to the embodiment shown in Figure 1, merely with different linking. The equivalent circuit is shown in Figure 7. This shows the parallel circuit comprising a spark gap and a varistor.

Figure 8 shows a very compact design achieved by using the varistor as a spark-gap spacer. In this arrangement, a varistor 2 is arranged as a spacer between two electrode plates 1 forming the spark gap. The varistor is designed as a circular disc with a relatively small diameter, so that a large free space is left between the electrode plates 1 next to the varistor 2, suitable and intended for the flashover of the spark gap. In addition,

moulded projections are provided on the electrode plates at the edge, which are advantageous for initiating the discharge.

In this case too, the equivalent circuit is again shown in Figure 8, with the varistor and the spark gap being connected in parallel.

The refinement shown in Figure 9 is similar in manner. In this case, the varistor is likewise used as a spacer, the varistor being designed as an annular element having a large free space in the centre which is suitable and intended for forming the spark gap between the electrode plates 1. In the centre, projections are formed on the electrode plates 1 in order to promote the development of the spark gap.

In the embodiment shown in Figure 10, a very compact design is achieved by using the varistor as a spark-gap spacer and as an electrode. In this case, there is a further varistor 2 arranged as a spacer between one electrode plate 1 (graphite electrode) and a disc-shaped varistor 2. This varistor designed as a spacer is of annular design, so that a large free space is formed in the centre for the flashover of the spark gap and for the arrangement of ignition tips on the varistor and the electrode plate.

The equivalent circuit shows the arrangement of a spark gap and a varistor in parallel and the series circuit comprising these components and a further varistor.

The invention is not restricted to the illustrative embodiments but can be varied in many ways within the scope of the disclosure.

All novel individual and combined features disclosed in the description and/or the drawing are regarded as essential to the invention.

Claims

1. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein the spark gap is formed by two electrode plates held apart from one another by means of a spacer made of insulating material, and a disc-shaped varistor is placed on at least one electrode plate in direct contact, the connecting conductors leaving from the side of the free electrode of the electrode plate and from the free side of the varistor and/or from the electrode plate.

2. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein the spark gap is formed by an electrode plate and a disc-shaped varistor which is held apart from the latter by means of a spacer made of insulating material and whose surface facing the electrode plate forms the second electrode of the spark gap, the connecting conductors primarily being provided on the mutually distant sides of the electrode plate and of the varistor.

3. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein the spark gap is formed by two disc-shaped varistors which are held apart by means of a spacer made of insulating material and whose mutually facing surfaces form the electrodes of the spark gap, the connecting conductors primarily being provided on the mutually distant sides of the varistors.

4. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein an electrode plate is arranged between two disc-shaped varistors with spacers made of insulating material being arranged in between, said electrode plate forming one electrode of the spark gap while those two surfaces of the varistors which face the electrode plate form the second electrodes of two spark gaps, the connecting conductors primarily being connected to the electrode plate and to those two surfaces of the varistors which are turned away from the electrode plate.

5. Circuit arrangement according to Claim 1, wherein that side of the electrode plate which is turned away from the spacer has a second spacer placed on it, with a further electrode plate placed on this, that side of the latter electrode plate which is turned away from the spacer having a second disc-shaped varistor placed on it in direct contact, with connecting conductors primarily leaving from the exposed surfaces of the two varistors and from the central electrode plate.

6. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein a varistor is arranged as a spacer between two electrode plates forming the spark gap.

7. Circuit arrangement according to Claim 6, wherein the varistor is disc-shaped, its diameter being smaller than the diameter of the electrode plates.

8. Circuit arrangement according to Claim 6, wherein the varistor is annular, its external diameter being the same as the diameter of the electrode plates.

9. Circuit arrangement according to one of Claims 6 to 8, wherein projections whose tips lie on the same radius protrude from the electrode plates in the area not occupied by the varistor on the sides turned towards each other.

10. Circuit arrangement for protecting electrical installations against overvoltage occurrences, comprising at least one varistor and one spark gap, wherein an electrode plate and a disc-shaped varistor have a further varistor, which is smaller in diameter or is annular, arranged between them as a spacer, with ignition tips or similar projections preferably protruding from the electrode plate and the disc-shaped varistor.

11. Circuit arrangement according to one of Claims 1 to 10, wherein the electrode plates are made of graphite.

12. Circuit arrangement according to one of Claims 1 to 11, wherein the electrode plates are formed by shallow circular discs.

13. Circuit arrangement according to one of Claims 1 to 12, wherein the varistors are designed as shallow circular discs or rings.

14. Circuit arrangement according to one of Claims 1 to 13, wherein the spacers are made of PTFE.

15. Circuit arrangement according to one of Claims 1 to 14, wherein the spacers are shallow annular discs.

16. Circuit arrangement according to one of Claims 1 to 15, wherein the planar surfaces of the disc-shaped varistors are provided with a highly electrically conductive coating, primarily of silver, aluminium, or graphite, preferably only on the surface which does not form the electrode of the spark gap.

17. Circuit arrangement according to one of Claims 1 to 16, wherein the 1-mA point of the varistor is far below the operating voltage of the spark gap, so that, in the event of an occurrence, the residual voltage of the varistor serves as an opposing voltage for extinguishing the arc of the spark gap.

Application No:	GB 9928700.5	**Examiner:**	Huw Jones
Claims searched:	1, 5, 11-17	**Date of search:**	27 April 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H2H - HAPB, HAPC
H1D - DGEA, DV

Int Cl (Ed.7): H01C - 7/12, 8/04
H01T - 1/16, 4/00, 4/02, 4/10, 4/12, 4/16
H02H - 9/04, 9/06

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP0893863 A1	(Harris Corp) - see fig. 3	1
X	US5708555	(Cooper) - see figs. 18, 20 and 24	1,5,11-17
A	US4908730	(Westrom) - see fig. 3	1
A	US4288833	(General Electric) - see figs. 5 and 6	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.